

A NEW *NEOLEPAS* (CIRRIPEDIA: THORACICA:  
SCALPELLIDAE) FROM AN ABYSSAL HYDROTHERMAL  
VENT, SOUTHEAST PACIFIC

Diana S. Jones

ABSTRACT

A new pedunculate barnacle, *Neolepas rapanuii* new species, has been discovered near hydrothermal vents at 23°S in the East Pacific, northwest of Easter Island, at a depth of 2,600 m. The species is distinct from *Neolepas zevinae*, which occurs at the same depth between 10° and 21°N off Mexico. Characters of the trophi, the capitulum and the peduncle distinguish the two species. Ova and nauplii of *N. rapanuii* are described, their structure being suggestive of a lecithotrophic mode of development.

The first vent cirriped was collected in 1979 at 21°N, from the crest of the East Pacific Rise off the west coast of Mexico. The specimens were described as *Neolepas zevinae* Newman, 1979, a new genus and species of the scalpellid subfamily Lithotryinae. Subsequently, *Neolepas* was transferred from the Lithotryinae to a new subfamily, the Eolepadinae (Buckeridge, 1983). Morphological and ontogenetic characters of *Neolepas* showed it to be a Mesozoic relic and the most primitive scalpellid genus living today. Additional populations of *N. zevinae* have since been found as far south as 10°N, at the same depth (Newman, 1985), but none have been found at the Galapagos vents. What may represent the same genus has also been reported from the Lower Triassic of New Caledonia (Buckeridge and Grant-Mackie, 1985).

In the western Pacific a primitive verrucomorph, *Neoverruca brachylepadoformis* Newman and Hessler, 1989, was discovered near abyssal hydrothermal vents at a depth of 3,600 m in the Mariana Back-Arc Basin.

A primitive balanomorph, *Eochionelasmus ohtai* Yamaguchi and Newman, 1990 was then discovered associated with an abyssal hydrothermal vent in the North Fiji Basin, southwestern Pacific, at a depth of 1,990 m.

Thus, the most primitive living members of the pedunculate Scalpellomorpha (*Neolepas*), the sessile Verrucomorpha (*Neoverruca*) and the sessile Balanomorpha (*Eochionelasmus*) are all known to occur associated with abyssal hydrothermal springs, a valuable glimpse of antiquity indeed (Newman, 1985). While these vent barnacles have highly divergent external morphologies, all show similar modifications of their appendages for the capture of extremely fine particulate material in gentle currents (Newman, 1979; Anderson and Southward, 1987; Newman and Hessler, 1989; Yamaguchi and Newman, 1990).

While working in the Senckenberg Museum, Frankfurt, Germany, in October 1990, Dr. Michael Türkay brought to my notice a jar of pedunculate barnacles collected at a depth of 2,600 m, from a hydrothermal vent area northwest of Easter Island (approximately 23°S) from the East Pacific Rise. These specimens were found to be a new species, *Neolepas rapanuii*, distinct from *N. zevinae*.

The East Pacific Rise and Galapagos vents are characteristically dominated by invertebrates having symbiotic bacteria, with clusters of tube-worms and bivalves being dominant (Grassle, 1986). In contrast, suspension-feeding barnacles, symbiotic gastropods and grazing limpets dominate the Mariana and Fiji vents of the western Pacific (Hessler et al., 1988). Newman (1989) commented that *N. zevinae* was not a conspicuous member of the macrofauna of communities at 21°N. However, *N. zevinae* has since been found to be more abundant at 15°N and at

10°N (W. Newman, pers. comm.). *Neolepas rapanuii*, represented by over 100 individuals, appears to be a common member of the vent community northwest of Easter Island. It now seems, contrary to previous reports, that *Neolepas* may be abundant in the eastern Pacific.

The following abbreviations are used in the text: CH, capitular height; CW, capitular width; L, left; NHM, Natural History Museum, London; PL, peduncular length; PW, peduncular width; R, right; (R), range; SMF, Senckenberg Museum, Frankfurt; USNM, Smithsonian Institution, National Museum of Natural History, Washington, D.C.; WAM, Western Australian Museum, Perth.

## DESCRIPTION

Suborder Scalpelloomorpha Newman, 1987

Family Scalpellidae Pilsbry, 1907

Subfamily Eolepadinae Buckeridge, 1983

*Neolepas* Newman, 1979

*Neolepas rapanuii* new species

Figures 1–6

**Material.**—Approximately 105 adult hermaphrodites and 50 juvenile stages, some attached to fragments of obsidian, from northwest of Easter Island, 23°32.52'S 115°34.01'W, at a depth of 2,600 m, collected 16.04.1989 by GEOMETEP 5, #219G.

**Type Material.**—Holotype, SMF Reg. No. 20364; paratypes, SMF Reg. No. 20365; NHM Reg. No. 1991.372-374; USNM Cat. No. 251833; WAM Reg. No. 136-91.

**Other Material.**—SMF Reg. Nos. 20366, 20367, 20368, 20369.

**Diagnosis.**—*Neolepas* with rostrum as high as median latus, long peduncle with scales proportionately smaller towards basis, with zone of peduncular scale production below capitulo-peduncular junction well defined. Mandible with fourth tooth between third tooth and inferior angle (Figs. 1, 2a–e, 2h–i, 3d).

**Description.**—ADULTS. Large individuals hermaphroditic. Capitulum subtriangular, laterally compressed. Eight capitular plates, calcified, approximate, growth lines distinct, covered by thin, transparent cuticle (Figs. 1, 2a, c–n).

Minute peduncular scales form in well defined growth zone immediately below capitulo-peduncular junction but whorls not well defined in this area. Successive whorls of older scales below this area more defined, scales closely set, triangular, apices extending freely from peduncle, spirally arranged, approximately 12 scales per whorl (Figs. 1, 2b1–b5). Peduncular length 2.4 times that of capitulum in largest specimen. Measurements (in centimeters) of seven largest specimens examined as follows:

	CH	CW	PL	PW
Range	1.45–1.03	0.82–1.15	2.01–3.84	0.36–1.00
Mean	1.24	1.01	2.95	0.55

Color in alcohol buff-yellow, with some brown, globular deposits on older peduncular scales and on distal regions of parietal plates. Young specimens more lemon-yellow.

Cirrus I set slightly apart from remaining cirri, both rami long, antenniform, posterior ramus longer than anterior ramus; antenniform portion of both rami more than half total ramal length; proximal segments of both rami protuberant

anteriorly, long setae on both rami, proximal posterior surfaces more setose than anterior surfaces (Fig. 4a, b). Cirrus II longer than cirrus I but shorter than remaining cirri, both rami antenniform, proximal segments of anterior ramus protuberant anteriorly, posterior ramus longer than anterior ramus, long setae on both rami, more dense in proximal regions, especially on posterior surfaces (Fig. 4c). Cirri III to VI all extremely long, fragile, segments oblong, elongate, especially distally, bearing from 1 or 2 (proximal segments) to 8 pairs (distal segments) of extremely long, fine setae on anterior faces (Fig. 4d, f). Chaetotaxy ctenopod, similar to *N. zeviniae*. Cirral counts for four specimens as follows:

CH	CW	PH	PW		CI	CII	CIII	CIV	CV	CVI	Ca
1.03	0.82	2.01	0.04	R	$\frac{26}{26}$	$\frac{36}{43}$	$\frac{52}{59}$	$\frac{61}{66}$	$\frac{64}{31^+}$	$\frac{68}{57^+}$	1
				L	$\frac{26}{29}$	$\frac{37}{43}$	$\frac{51}{58}$	$\frac{64}{64}$	$\frac{76}{18^*}$	$\frac{66}{68}$	1
1.11	0.92	2.27	0.37	R	$\frac{28}{26^+}$	$\frac{41}{44}$	$\frac{52}{57}$	$\frac{63}{65}$	$\frac{54^+}{65}$	—	1
				L	$\frac{27}{32}$	$\frac{42}{46}$	$\frac{48^+}{57}$	$\frac{61}{56^+}$	$\frac{65}{67}$	—	1
1.20	0.94	2.62	0.36	R	$\frac{25}{30}$	$\frac{37}{22^+}$	$\frac{52}{58}$	$\frac{60}{52^+}$	$\frac{61^+}{61}$	$\frac{35^+}{31^+}$	1
				L	$\frac{25}{26^+}$	$\frac{30^+}{40}$	$\frac{39^+}{27^+}$	$\frac{48^+}{59^+}$	$\frac{50^+}{62}$	$\frac{37^+}{49^+}$	1
1.39	1.15	3.41	1.00	R	$\frac{30}{36}$	$\frac{38}{46}$	$\frac{52}{54^+}$	$\frac{67}{66}$	$\frac{33^+}{69}$	$\frac{65}{44^+}$	1
				L	$\frac{28}{33}$	$\frac{37}{45}$	$\frac{41^+}{41^+}$	$\frac{64}{65}$	$\frac{70}{60^+}$	$\frac{72}{73}$	1

\* regenerated

Caudal appendages small, broad, blunt, uni-articulate, less than half height of basal segment of pedicel of cirrus VI (Fig. 4d, e). Penis long, approximately one-quarter to one-fifth length of cirrus VI, finely annulated, tapering distally (Fig. 4g, h).

Labrum not strongly bullate, crest of labrum concave with minute, sharp teeth in single row (Fig. 3a, b). Mandibular palps relatively small (Fig. 3c). Mandible with three main teeth and clear indication of fourth between third and inferior angle; first simple, second and third with minute denticles along their broad superior margins, denticles not rolling over on to inner surface of mandible, less strongly developed fourth tooth with minute denticles along its superior margin preceding larger denticles of broad inferior angle; no enlarged spine on superior margin of second tooth; mandible clothed with combs of fine setae, superior and inferior margins with longer, fine setae (Fig. 3d). Maxillule simple, with straight cutting edge bearing many fine to medium spines, spines slightly enlarged at superior margin, superior and inferior margins clothed with long, fine setae (Fig. 3e). Maxilla simple, blunt, setose (Fig. 3f).

*Supplementary Description.*—OVA. Yolky ova, large, ellipsoidal, measuring  $300 \times 500 \mu\text{m}$ , were found in two of the seven adult individuals examined internally. Ova, mainly in a single layer, were contained in a pair of saucer-shaped ovigerous lamellae of approximately 3 mm diameter (Fig. 5a). Each lamella, containing approximately 70 eggs, was attached to an irregular "Y"-shaped ovigerous frenum

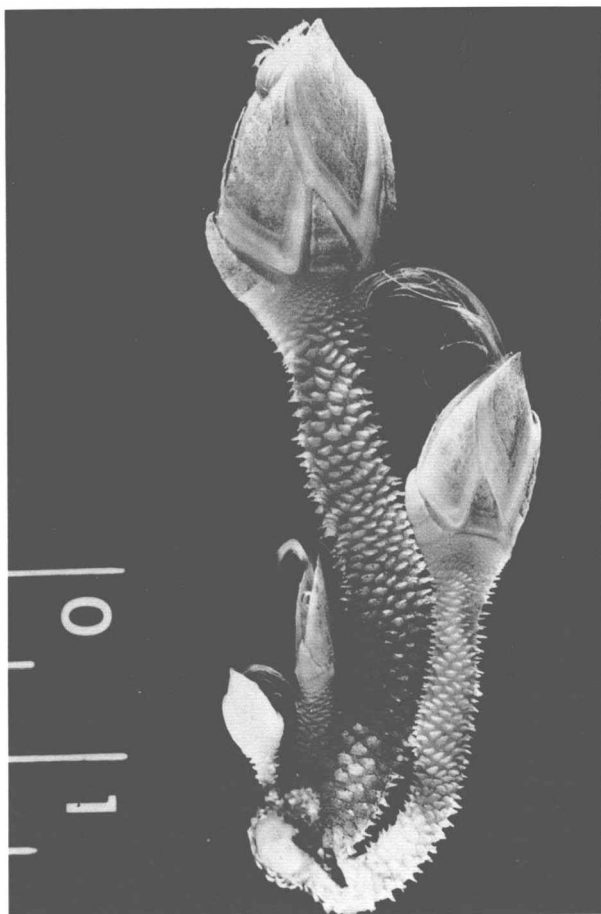


Figure 1. *Neolepas rapanuii* sp. nov.: group of juvenile and adult individuals (scale in cm).

just below the adductor muscle, with the smaller arm of the frenum towards the occludent margin and the longer arm towards the carinal margin. Ovigerous setae (terminology of Walker, 1983) occur in groups on the central, distal region of each ovigerous frenum, close to the margin on the inner face, but appear absent from the outer distal margins of the occludent and the carinal arms.

**NAUPLIUS.** Nauplii with caudal furca, caudal spine, fronto-lateral horns, and short limbs clothed with setulose setae in two of seven adults examined (Fig. 5b). It is unknown whether these are released as feeding or non-feeding nauplii, but there were no gnathic spines on the second antennae or mandibles. The nauplii are relatively well developed and the limbs are provided with 'flotation setae.' It seems unlikely that they go on to become cyprids before being released.

Dimensions (in centimeters) of individuals bearing eggs or embryos:

CH	CW	PL	PW	
1.39	1.15	3.41	1.00}	nauplii with caudal spines and short appendages eggs
1.24	1.05	3.47	0.40}	
1.45	1.03	3.03	0.99}	
1.28	1.15	3.84	0.44}	

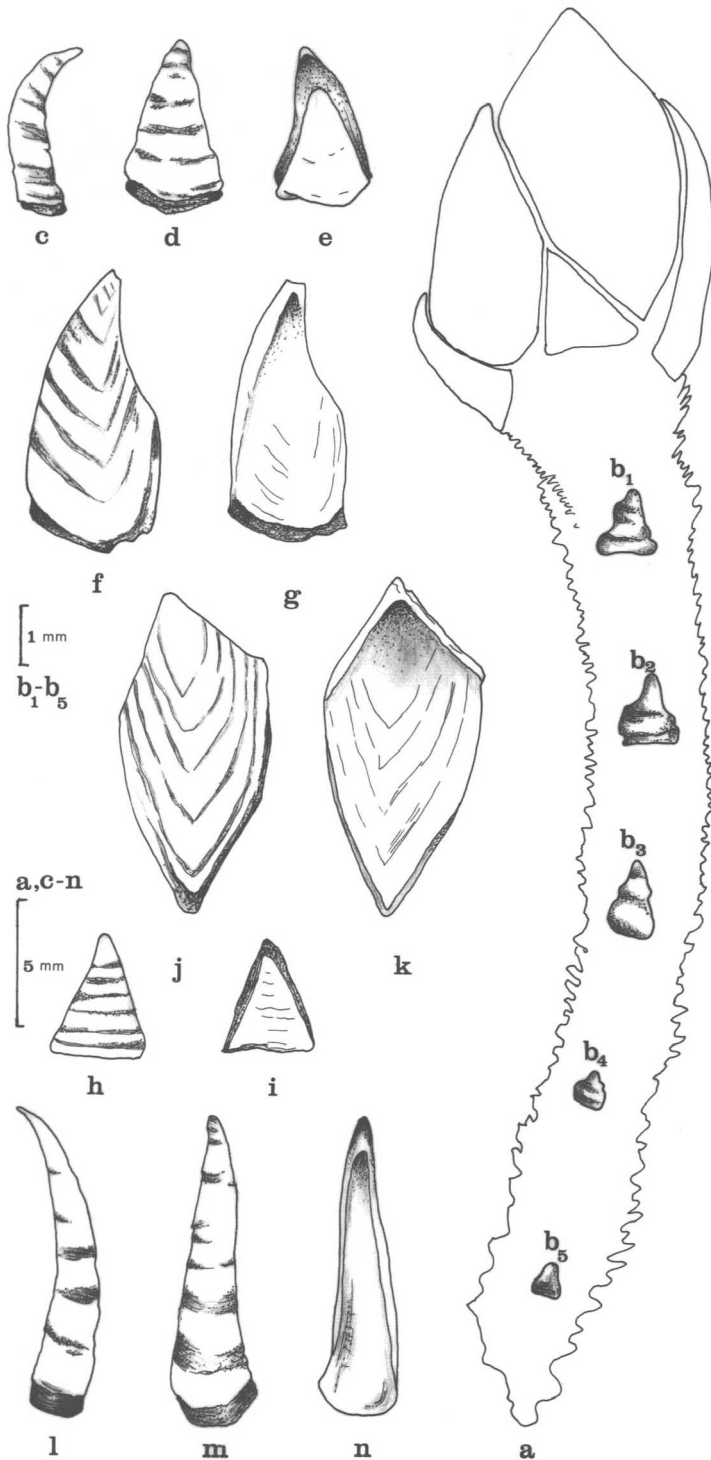


Figure 2. *Neolepas rapanuii* sp. nov.: conchological characteristics: a, whole animal, lateral view of right side; b<sub>1</sub>-b<sub>5</sub>, peduncular scales taken at 5 mm intervals down length of peduncle; c-e, lateral, frontal, inner view of rostrum; f, g, lateral, inner view of scutum; h, i, lateral, inner view of median latus; j, k, lateral, inner view of tergum; l-n, lateral, dorsal, inner view of carina.

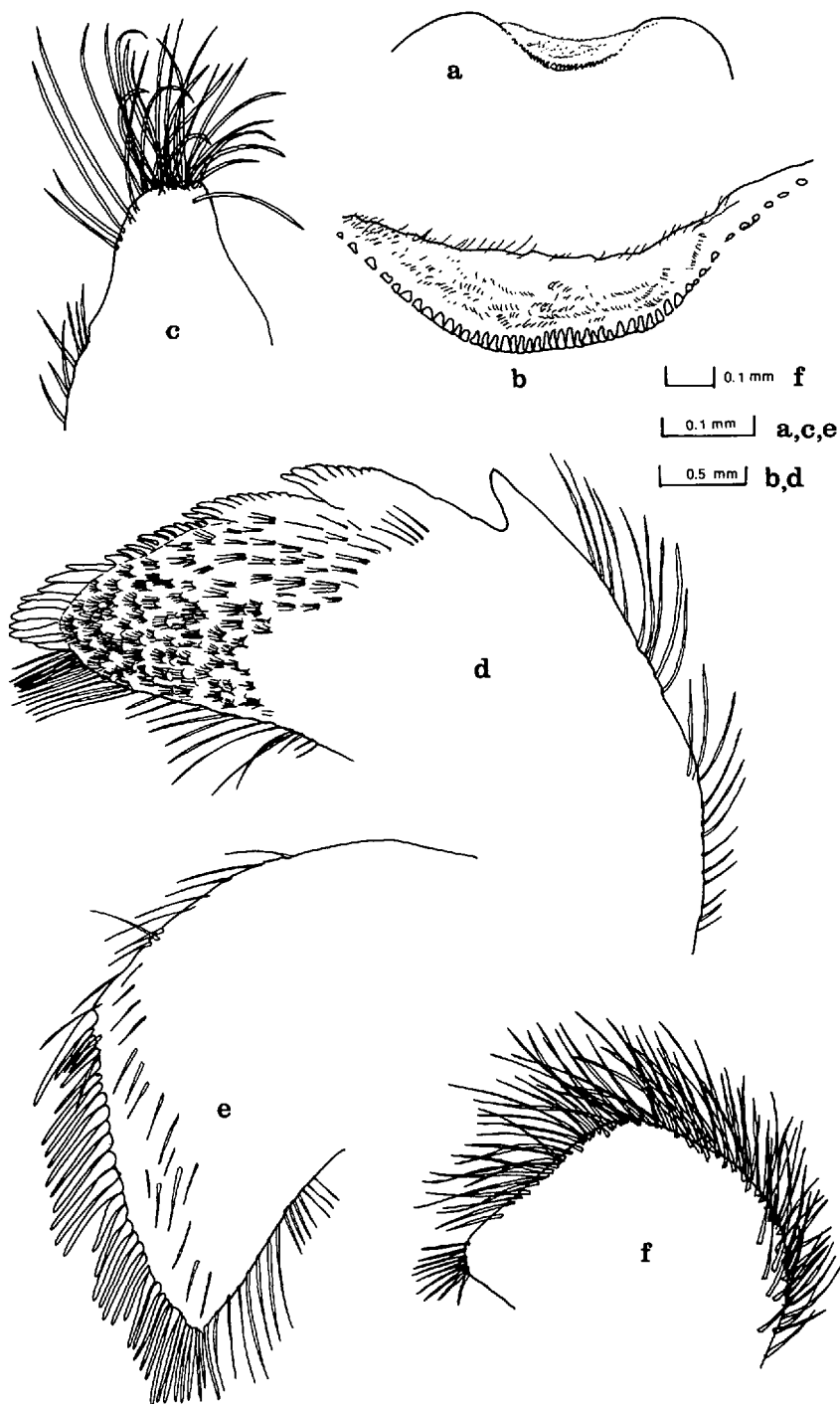


Figure 3. *Neolepas rapanuii* sp. nov.: trophi: a, labrum; b, crest of labrum enlarged; c, left mandibular palp; d, left mandible; e, left maxillule; f, left maxilla.

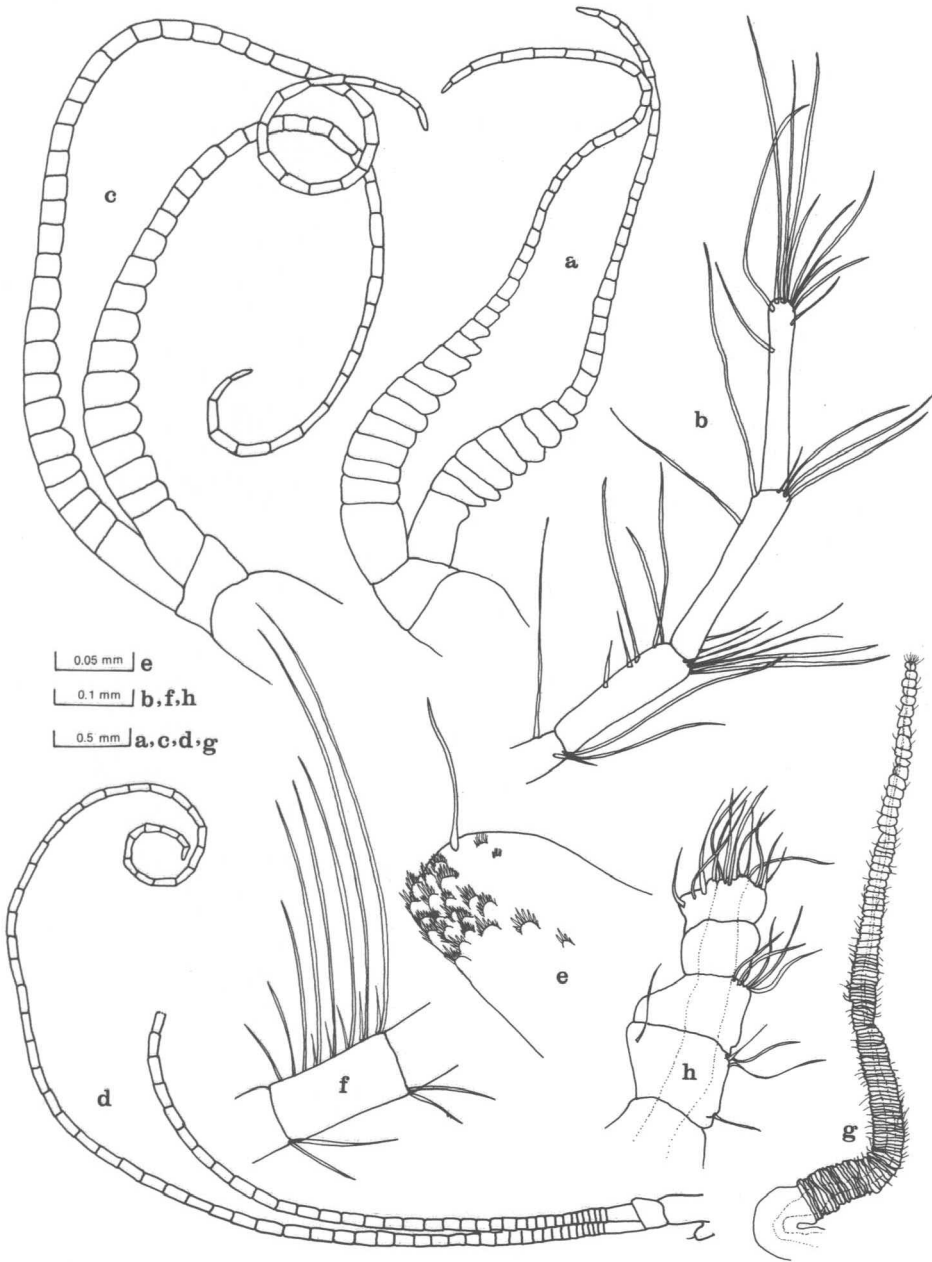


Figure 4. *Neolepas rapanuii* sp. nov.: cirri: a, cirrus I; b, distal segments of anterior ramus of cirrus I; c, cirrus II; d, cirrus VI and caudal appendage; e, caudal appendage enlarged; f, intermediate segment of posterior ramus of cirrus VI; g, penis; h, tip of penis enlarged.

**JUVENILE.** A number of juvenile stages were found attached to the basal area of the peduncles of established hermaphrodites (Fig. 6). Juveniles were most commonly attached at the base, or less commonly close to the base. Only a few were found on the peduncle, singly attached, one per hermaphrodite and mostly

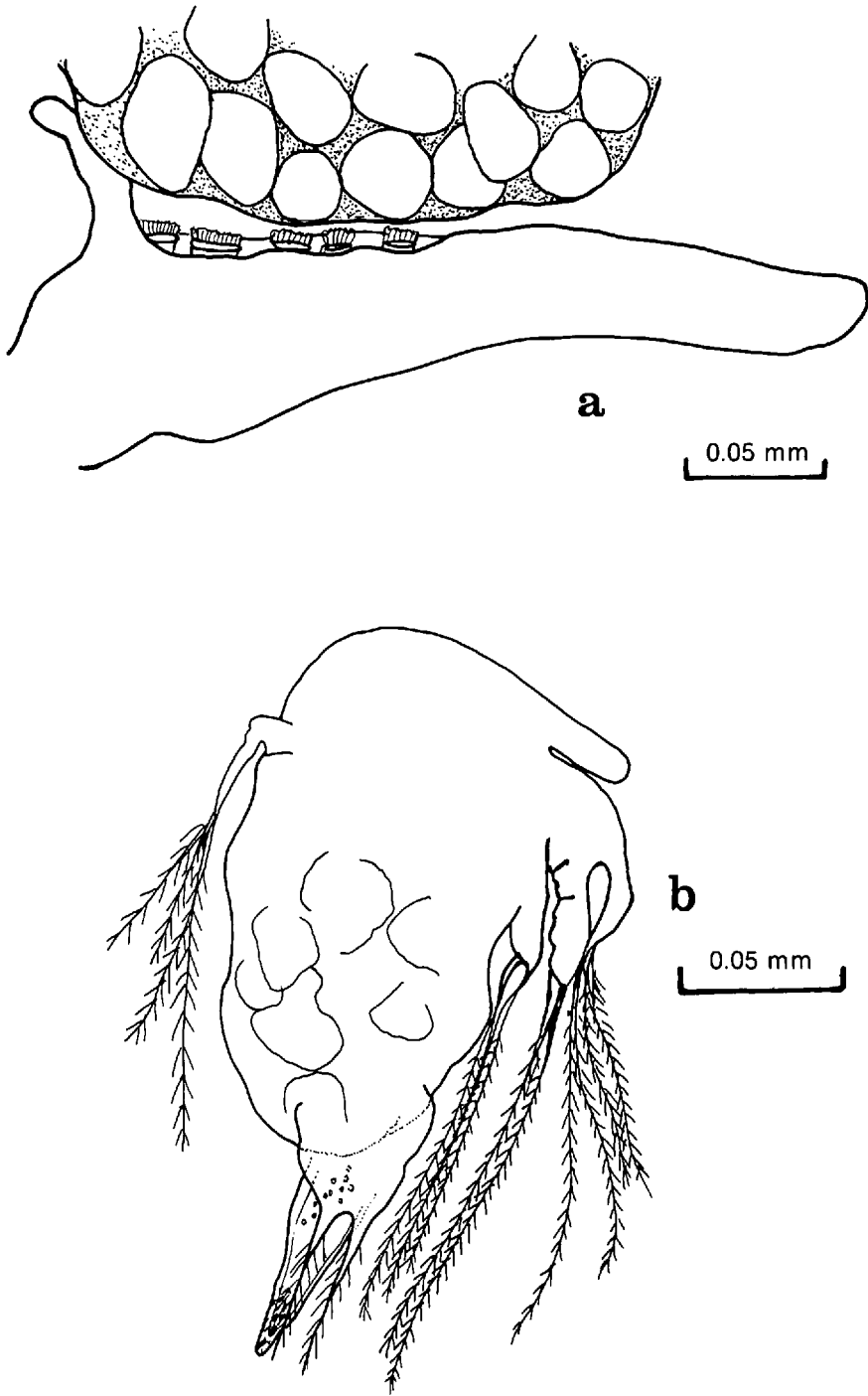


Figure 5. *Neolepas rapanuii* sp. nov.: a, ovigerous frenum; b, structure of naupliar larva dissected from ovigerous lamella.



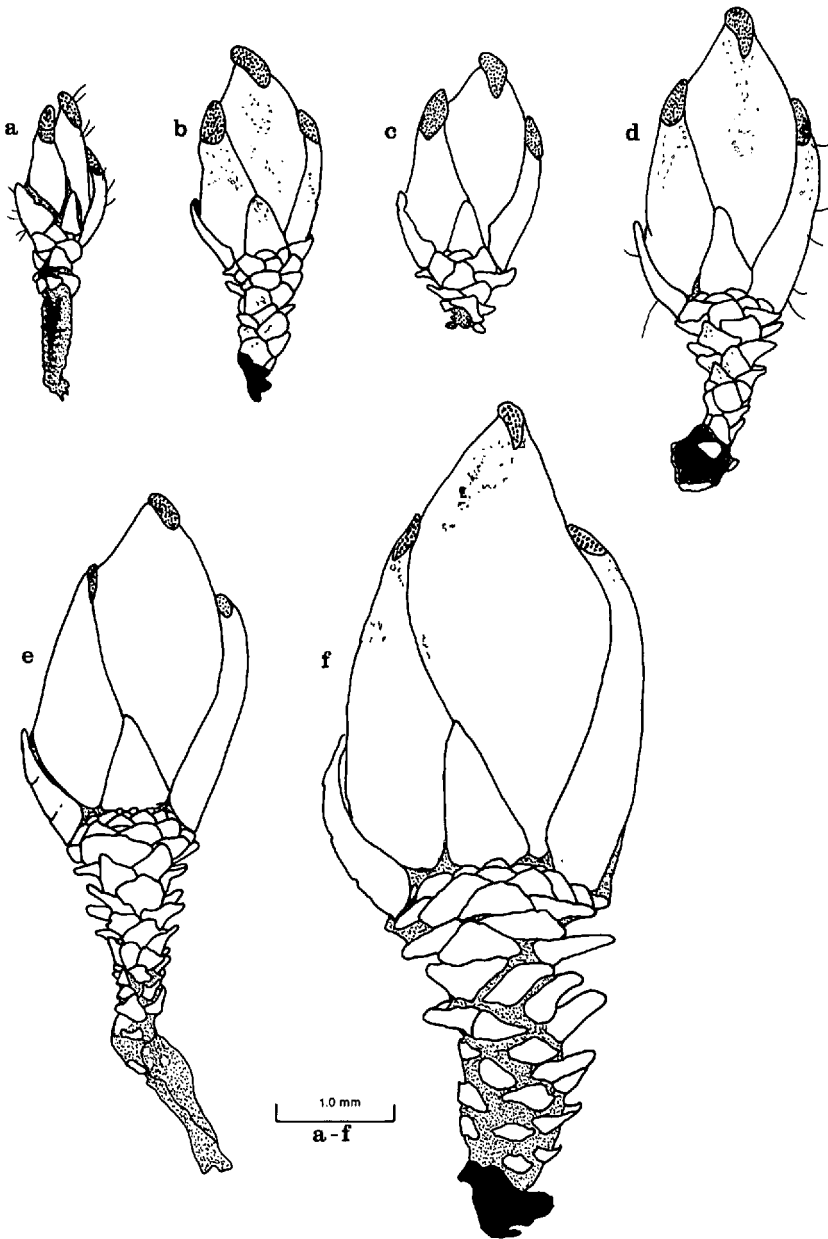


Figure 6. *Neolepas rapanuii* sp. nov.: a-f, ontogenetic stages of juveniles.

less than 10 mm above the substratum. There were two instances where a juvenile was found attached to the scutum of an hermaphrodite, and one where the hermaphrodite harbored one juvenile attached approximately 5 mm below the rostrum and one juvenile approximately 10 mm above the peduncular base.

The peduncle was naked in the smallest juvenile stages found, but capitular armature characteristic of adults was already present.

*Etymology.* — The species has been named for its proximity to Easter Island (Rapa Nui).

## DISCUSSION

*Neolepas rapanuii* differs from *N. zeviniae* in characters of the trophi, the capitulum and the peduncle. The new species is distinguished by the presence of a fourth tooth on the cutting edge of the mandible, the absence of an elongated spine on the superior margin of the second tooth, and the denticles along the broad superior margins of the cutting edges of the second and third teeth not rolling over on to the inner surface of the mandible to any extent. Furthermore, the rostrum is as high as but not higher than the median latus in *N. rapanuii* and the peduncular scales are less robust than those of *N. zeviniae*. The zone of peduncular scale production below the capitulo-peduncular junction is well developed, more extensive, and the peduncular scales are proportionately smaller and more numerous than those of *N. zeviniae* over all peduncular areas.

Hydrothermal vents are for the most part associated with sea-floor spreading centers at abyssal depths. They are spatially discrete, with profoundly different temperature and chemical characters from the deep sea surrounding them, and are ephemeral (Wilson and Hessler, 1987; Van Dover, 1990). Hydrothermal vent invertebrates must, therefore, rely on dispersal in order to maintain their ranges. Most information on the life histories of vent species indicates at least a brief period of planktonic ability, although nothing is known about their capacity for dispersal along oceanic ridge axes (Lutz et al., 1984).

The larval stages of development of *Neolepas* are incompletely known, as is the case for most deep-sea crustaceans. The small clutches of large, yolky eggs in *N. zeviniae* and *N. rapanuii*, and the apparent lack of gnathic spines on the limbs of the nauplii indicate lecithotrophy (Barnes, 1989) with abbreviated larval stages and that might limit capabilities for long-range dispersal. However, the remarkable length and setulose nature of the naupliar setae of *N. rapanuii*, combined with the weak development of the limbs, indicate that the nauplii are well equipped for drifting and may be released at this stage. The naupliar setae are remarkable in being setulose, indicating that the larvae are brooded to a more advanced stage than in typical lepadomorphs (Moyse, 1987) and balanomorphs (Newman, 1965; Egan and Anderson, 1989). Non-feeding larvae have the potential to drift substantial distances on deep sea currents before metamorphosis into the cyprid stage and settlement occur. Low temperatures encountered in the deep sea away from vents may also extend the period available for the dispersal of drifting larvae, since the slow metabolic rate known for some deep sea animals may also be true for larvae.

No species of *Neolepas* or other hydrothermal barnacles have been found at the Galapagos vents. The Galapagos hydrothermal springs, in contrast to areas where barnacles have been found associated with hydrothermal activity, are benign (no black or white smokers) and the waters are relatively cool (R. Hessler, pers. comm.). In the hydrothermal environment, factors such as the turbulent flushing up of food (or appropriate amounts of food) in the form of chemosynthetic bacteria, and the refugium provided against predators and competitors, are important requirements of the barnacles rather than hot water per se.

*Neolepas zeviniae* populations between 21°N and 10°N on the East Pacific Rise are clearly differentiated from the *N. rapanuii* population at 23°S on the East Pacific Rise, indicating that there has been no recent genetic exchange between these populations. The fact that the Galapagos vents are apparently unfavorable for hydrothermal barnacles may be in good part responsible for the present separation of these two populations of *Neolepas*.

Water chemistry and temperatures of vents are not known at 23°S. However,

information from other hydrothermal vents suggests that environmental differences between vents are significant and correlated with differences between biotas (Newman, 1979; Butterfield et al., 1988; Van Dover, 1990). Potentially different environments, limited dispersal capabilities, and the discontinuity of suitable habitats may have promoted speciation of *Neolepas* following geographic isolation between the northern and southern localities on the East Pacific Ridge.

Lecithotrophic larvae could metamorphose and settle at the parental vent if conditions are acceptable, but if the conditions deteriorate they have the option to disperse (Lutz et al., 1984), and the nauplii of *N. rapanuii* apparently have the potential to drift for extended periods of time. Dispersal of lecithotrophic larvae is a step-wise process, with oceanic ridge axes acting as discrete dispersal corridors. The populations of *N. zeviniae* at 21°N, 15°N and 10°N may be the results of such a stepping-stone process. The wide range of sizes in the *N. rapanuii* sample, combined with the extremely small clutch size of very large eggs in this species, adds credence to Newman's (1979) suggestion that breeding is continuous in *Neolepas*.

#### ACKNOWLEDGMENTS

Thanks are due to Dr. M. Türkay who first brought these specimens to my attention and for allowing me to work on this material. I am most grateful to Prof. W. Newman, Prof. D. Anderson, Dr. G. Poore, Dr. F. Wells and two anonymous referees for their helpful and constructive comments on various drafts of the manuscript. The photograph (Fig. 1) of *Neolepas rapanuii* was taken by Mr. C. Bryce, Western Australian Museum.

#### LITERATURE CITED

- Anderson, D. T. and A. J. Southward. 1987. Cirral activity in barnacles. Pages 135–174 in A. J. Southward, ed. *Barnacle biology. Crustacean issues, Vol. 5*. Balkema, Rotterdam.
- Barnes, M. 1989. Egg production in cirripedes. *Oceanogr. Mar. Biol. Ann. Rev.* 27: 91–166.
- Buckeridge, J. S. and J. A. Grant-Mackie. 1985. A new scalpellid barnacle (Cirripedia: Thoracica) from the Lower Jurassic of New Caledonia. *Géologie France* 1: 77–80.
- Butterfield, D., R. E. McDuff, M. D. Lilley, G. J. Massoth and J. E. Lupton. 1988. Chemistry of hydrothermal fluids from the ASHES vent field: evidence for phase separation. *Eos* 69(44): 1468.
- Egan, E. A. and D. T. Anderson. 1989. Larval development of the chthamuloid barnacles *Catomerus polymerus* Darwin, *Chamaesipho tasmanica* Foster and Anderson and *Chthamalus antennatus* Darwin (Crustacea: Cirripedia). *Zool. J. Linn. Soc.* 95: 1–28.
- Hessler, R., P. Lonsdale and J. Hawkins. 1988. Patterns on the ocean floor. *New Scientist*. 117: 47–51.
- Grassle, J. F. 1986. The ecology of deep-sea hydrothermal vent communities. *Adv. Mar. Biol.* 23: 301–362.
- Lutz, R. A., D. Jablonski and R. D. Turner. 1984. Larval development and dispersal at deep-sea hydrothermal vents. *Science* 226: 1452–1454.
- Moyse, J. 1987. Larvae of lepadomorph barnacles. Pages 329–362 in A. J. Southward, ed. *Barnacle biology. Crustacean issues, Vol. 5*. Balkema, Rotterdam.
- Newman, W. A. 1965. Prospectus on larval cirriped setation formulae. *Crustaceana* 9: 51–56.
- . 1979. A new scalpellid (Cirripedia); a Mesozoic relic living near an abyssal hydrothermal spring. *Trans. S. Diego Soc. Nat. Hist.* 19: 153–167.
- . 1985. The abyssal hydrothermal vent invertebrate fauna: a glimpse of antiquity? *Bull. Biol. Soc. Wash.* 6: 231–242.
- . 1987. Evolution of cirripeds and their major groups. Pages 3–42 in A. J. Southward, ed. *Barnacle biology. Crustacean issues, Vol. 5*. Balkema, Rotterdam.
- . 1989. Juvenile ontogeny and metamorphosis in the most primitive living sessile barnacle. *Bull. Mar. Sci.* 45: 467–477.
- and R. R. Hessler. 1989. A new abyssal hydrothermal verruciform (Cirripedia; Sessilia): the most primitive living sessile barnacle. *Trans. S. Diego Soc. Nat. Hist.* 21(16): 221–235.
- Van Dover, C. L. 1990. Biogeography of hydrothermal vent communities along sea-floor spreading centres. *TREE* 5(8): 242–246.

- Walker, G. 1983. A study of the ovigerous fraena of barnacles. *Proc. Roy. Soc. B* 218: 425–442.
- Wilson, G. D. F. and R. R. Hessler. 1987. Speciation in the deep sea. *Ann. Rev. Ecol. Syst.* 18: 185–207.
- Yamaguchi, T. and W. A. Newman. 1990. A new and primitive barnacle (Cirripedia: Balanomorpha) from the North Fiji Basin abyssal hydrothermal field, and its evolutionary implications. *Pacif. Sci.* 44: 135–155.

DATE ACCEPTED: June 15, 1992.

ADDRESS: *Western Australian Museum, Francis Street, Perth, Western Australia, Australia 6000.*